

A module for a device for the thermal treatment of workpieces

TECHNICAL FIELD

The present disclosure relates to a module for a device for the thermal treatment of workpieces, to a device for the thermal treatment of workpieces having at least one said module, and to a suction device for suctioning particles and/or gases which are emitted or produced during a thermal treatment of a workpiece.

BACKGROUND

A thermal treatment of workpieces is part of a multiplicity of different production and processing processes. These include, for example, the sintering of ceramics, the melting or the heat treatment of metals or ores, the firing of cement or cement precursors, the treatment of mineral granules and many others.

Within the meaning of the present invention, the term “workpiece” includes all the largely solid materials to be treated. These can be present, for example, in the form of larger, cohesive units, for example as green compacts, blanks or semifinished products. Non-cohesive units, such as powder, green powder or other precursors, are also included under the term “workpiece”.

Within the meaning of the present invention, a thermal treatment of a workpiece is understood in principle to mean all types of treatments in which the workpiece is at least partially heated. These include, for example, sintering processes, surface treatments, melting processes, the firing of layers on a surface and the drying of surfaces, in particular the drying of paints and varnishes on surfaces.

The thermal treatment of workpieces is possible in principle by a wide variety of heating processes, such as, for example, electrical heating, heating by means of exothermic reactions, in particular the combustion of gases, or
5 the absorption of radiation.

For an efficient design of the heating processes, in particular the energy consumption is a relevant variable. In this case, the heating of workpieces by absorption of radiation is particularly advantageous from the point of view of efficiency. On the other hand, the devices required for this purpose, for ex-
10 ample laser systems, are more expensive to procure and maintain than, for example, simple gas burners.

In addition to the energy consumption, gas burners have the disadvantage that they can only be controlled punctually and precisely to a limited
15 extent.

Various devices and methods for generating and using radiation for the thermal treatment of workpieces are known from the prior art, but these devices and methods have the abovementioned individual disadvantages and
20 limitations in terms of flexibility, process speed and energy efficiency.

SUMMARY OF THE DISCLOSURE

5 It is therefore the object of the present invention to provide an efficient and powerful device for the thermal treatment of workpieces.

10 This object is achieved according to the invention by a module for a device for the thermal treatment of workpieces according to claim 1 and by a device for the thermal treatment of workpieces having said modules according to claim 24.

According to the invention, the module for a device for the thermal treatment of workpieces has the following features:

- 15 - a thermally conductive base block with a base block side,
- at least one electrical input,
- an LED luminous area, wherein the LED luminous area is formed by at least one LED module, wherein the at least one LED module is arranged on the base block side and is electrically conductively connected to the electrical input,
- 20 - a module luminous area with a module power density (BPD), wherein the module power density (BPD) corresponds to the sum of the power, emitted as light, of the LED modules arranged on the base block side per total area of the base block side,
- a separating layer between LED module and base block side, wherein
25 the separating layer is electrically insulating and thermally conductive,
wherein the module further comprises at least one electrical output to which the at least one LED module is electrically conductively connected, the separating layer is electrically insulating, and the module power density (BPD) is greater than 20 W/cm^2 .

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The thermally conductive base block is not restricted in its geometry to rectangular blocks. The base block can, for example, have the basic shape of

a triangle, hexagon or another polygon with a base block thickness d . The base material of the base block preferably consists of copper, since it is particularly well thermally conductive.

5 The at least one electrical input and output can be provided in the form of simple contacts or plugs.

10 An LED module preferably has an electrical contacting option, a socket and an LED chip. An LED module can have a plurality of sockets and LED chips.

The size of an LED module can also be matched to the size of the base block, so that it covers exactly the area of the base block side, in order to reduce the number of components and thus complexity and manufacturing costs. In a particularly advantageous embodiment, the separating layer and LED luminous area are produced directly on the base block.

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The LED luminous area is formed by the area of all the LED chips located in the LED modules arranged on the base block side. The LED luminous area is thus the sum of those areas on the module which actually emit light. The emitted light is in the wavelength range of 100 to 1000 nm, preferably 200 to 600 nm.

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The module luminous area describes the entire area of a module which is formed by the base block side. Non-light-emitting intermediate spaces between the LED modules or LED chips likewise contribute to this.

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The module power density (BPD) describes the power, emitted as light, per area of the base block side. The base block side of the module contains light-emitting areas, the areas of the LED chips and non-light-emitting areas, for example intermediate spaces and edges.

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The separating layer is preferably formed by aluminum nitride. The decisive factor is the choice of a material with an electrically insulating effect and at the same time good thermal conductivity. The separating layer does not have to be applied over the full area on the base block side. For example, the separating layer can be provided only in regions in which an LED module is arranged.

The thickness of the separating layer is preferably less than 500 μm , more preferably less than 425 μm , more preferably less than 350 μm , more preferably less than 275 μm , more preferably less than 200 μm , more preferably less than 100 μm , more preferably less than 40 μm , more preferably less than 10 μm , more preferably less than 2 μm . By means of such smaller thicknesses, the dissipation of the heat from the LED modules can be optimized.

In a particularly preferred embodiment, the separating layer has a thickness of (approximately) 375 μm , which can be an optimized compromise between heat dissipation and stability.

Within the meaning of the present invention, the term "workpiece" includes all the largely solid materials to be treated. These can be present, for example, in the form of larger, cohesive units, for example as green compacts, blanks or semifinished products. Non-cohesive units, such as powder, green powder or other precursors, are also included under the term "workpiece".

A module power density (BPD) greater than 20 W/cm² has proven to be particularly advantageous since, given a corresponding module power density (BPD), a multiplicity of materials can already be thermally treated.

A module power density (BPD) of, for example, 20 W/cm² already enables a sufficient input of energy into the surface of some workpieces to be

thermally treated. For example, it is possible to heat a workpiece which absorbs very well to temperatures of 1100°C.

5 In principle, there is a relationship between module power density (BPD) and achievable temperature of a workpiece to be thermally treated. This relationship is not necessarily linear over the temperature since, in various temperature ranges, various factors are decisive for the achieved temperature. In particular in high temperature ranges, the achieved temperature can be dependent on the power density in the form of the fourth root.

10 A further increase in the module power density (BPD) is advantageous since, with increasing module power density (BPD), further thermal treatment possibilities become possible, such as, for example, a thermal treatment at even higher temperatures.

15 The module according to the invention has the advantage that a cost-effective and robust alternative to lasers or other optical systems is created, with simultaneously high achievable powers. By using LEDs, a particularly energy-efficient and thus cost-effective generation of light during operation is made possible. LEDs are also more cost-effective to procure than, for example,
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Furthermore, by means of the device according to the invention, a homogeneous thermal treatment of workpieces is possible in a surprisingly simple manner.

5 The object described above is likewise achieved by a device according to the invention for the thermal treatment of workpieces, wherein the device comprises at least one module according to the invention.

10 The device can already be formed by one module, but the device is advantageously formed by a plurality of modules. This enables a simple implementation of the addressed scalability.

15 Due to the high power densities of more than 20 W/cm^2 , a large amount of heat can arise, which is to be conducted away from the LED modules in order to avoid damage. The thermally conductive separating layer conducts the heat to the thermally conductive base block. The thermally conductive base block in turn conducts the heat away from the LED modules.

20 In one aspect of the invention, the module according to the invention comprises a cooling device configured to bring the base block into thermal contact with a coolant. If the thermally conductive base block cannot dissipate enough heat from the LED modules due to the environment, it can be cooled by means of the cooling device, so that the maximum heat that can be dissipated is increased.

25 In a preferred aspect of the invention, the cooling device comprises at least one coolant inlet and at least one coolant outlet. Thus, a flow of the coolant can be conducted into the cooling device and out of the cooling device. Thus, a constant exchange of the coolant is enabled, so that the heat
30 that can be dissipated is further increased.

In a particularly preferred aspect of the invention, the cooling device is configured to conduct a coolant via the at least one coolant inlet into the base block and via the at least one coolant outlet out of the base block. The cooling device and thus the coolant inlets and outlets can be part of the base block. Thus, a direct contact between the coolant and the base block is ensured, which further increases the quantity of heat that can be dissipated.

The at least one coolant inlet and coolant outlet can be provided in the form of hose connections or hose couplings. The coolant is preferably water.

According to a further embodiment of the module, the LED luminous area covers at least 60%, preferably at least 70%, more preferably at least 80%, more preferably at least 90% of the base block side.

According to an embodiment of the module, the LED luminous area has a luminous surface power density (LPD). The luminous surface power density (LPD) describes the power, emitted as light, per LED luminous area, for example per cm² LED luminous area.

The larger the region of the base block side covered with LED luminous area, the more homogeneous the light irradiation on a workpiece arranged at a working distance. Furthermore, with a large coverage, lower luminous surface power densities (LPD) are required to achieve a specific module power density (BPD).

According to a further embodiment of the module, a plurality of LED modules form the luminous area and the LED modules are configured to emit different wavelength ranges.

The maximum achievable luminous surface power density (LPD) and thus also the module power density (BPD) are limited by the available LEDs. The maximum power of LEDs is substantially wavelength-dependent. For the

present invention, the maximum available LED power densities of the respective wavelength are particularly advantageous.

5 The workpieces to be thermally treated absorb light of different wavelengths to different extents, wherein the absorption also depends on the temperature, in particular surface temperature, of the workpiece. The advantage of this embodiment consists in that light of different wavelengths can be used for the thermal treatment of the workpieces, depending on the surface temperature of the workpiece to be treated.

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By means of the choice of different wavelength ranges, a wavelength range optimized for a workpiece to be thermally treated can thus be selected.

15 In a development of the aforementioned embodiment, a first wavelength range is in the range 425 to 600 nm and a second wavelength range is in the range 200 to 425 nm.

LEDs which emit in the first wavelength range are commercially easily and cost-effectively available, in particular 440 or 455 nm.

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In the second wavelength range, LEDs which emit, for example, in the wavelength range 405, 395, 385, 375 or 365 are preferably used, since they are likewise easily and cost-effectively available.

25 According to a further embodiment of the module, a plurality of LED modules form the luminous area and a plurality of electrical inputs and outputs are present, which are each electrically conductively connected to an LED module or an LED module group.

30 An LED module group is formed by a combination of individual LED modules, for example of LED modules located in a row or in a region.

This embodiment has the advantage that individual LED modules or LED module groups can be electrically driven. Thus, for example, the intensity of the light emitted by the module can be spatially varied.

5 For the case in which the LED modules also emit in different wavelength ranges, it is thus possible, for example, firstly to radiate light in the first or second wavelength ranges onto a surface of the workpiece in order to heat the surface of the workpiece until a predefined surface temperature of the workpiece is reached and subsequently to radiate light in the second or first
10 wavelength ranges. The simultaneous radiation of light of different wavelength ranges is also possible, for example.

The versatility and usability of the modules is also improved as a result.

15 According to a further embodiment of the module, the base block has one or more channels, preferably a lamellar structure, allowing flow of a coolant, preferably a cooling fluid, via the coolant inlet and coolant outlet. The channels can form a structure arranged in the interior of the base block, which structure brings about a good heat exchange between base block and
20 cooling medium.

A lamellar structure, or another form of the channels, increases the area via which heat can be dissipated from the base block into the coolant. The possible cooling power is thus increased. A lamellar structure is particularly
25 effective here.

According to a further embodiment of the module, the distance between the base block side and a coolant introducible via the coolant inlet is less than 1 cm.

30 This permits a rapid and efficient heat dissipation. In particular when using LED luminous areas with a high luminous surface power density (LPD),

the thermal power occurring as a by-product can thus be introduced into the coolant via the material of the base block. At distances of more than 1 cm, it can occur, for example, that the coefficient of thermal conductivity of the material of the base block is not high enough, which limits the possibility of heat dissipation. As a result, the individual LEDs can overheat. In the extreme case, the structural integrity of the module can be damaged as a result. At distances of less than 1 cm, this is prevented.

According to some embodiments, the base block side can be a base block top side. In further preferred embodiments, the base block top side is the side of the base block facing the workpiece.

In further preferred embodiments, the base block further comprises a base block bottom side and base block side surfaces, wherein the base block bottom side can be opposite or obliquely opposite the base block top side.

According to an embodiment of the module, connection possibilities are provided on the base block bottom side.

The connection possibilities can be provided, for example, in the form of mechanical connection possibilities such as threaded bores, eyelets or latching connections and/or in the form of form-fitting connection possibilities such as gluing, welding or soldering. A fastening of the module, for example, to a holder is made possible as a result.

According to a further embodiment of the module, the electrical input and/or electrical output and/or the coolant inlet and/or the coolant outlet are arranged on the base block bottom side.

This permits a particularly simple contacting from the base block bottom side.

According to a further embodiment of the module, the electrical input and/or electrical output and/or the coolant inlet and/or the coolant outlet are arranged on a base block side surface.

5 This permits a plugging together and connecting together of a plurality of modules to form a device according to the invention comprising a plurality of modules in a particularly simple manner.

10 According to an embodiment of the device, the device is formed and/or expandable in a modular manner by modules arranged next to each other.

 This enables the described scalability in a simple manner. Depending on the workpiece to be thermally treated, the device can be adapted quickly and easily and, for example, can be increased.

15 According to a development of this embodiment, a respective electrical input and/or coolant inlet of a subsequent module is connected to an electrical output and/or coolant outlet of a preceding module.

20 This is possible in a particularly simple manner if the electrical input and/or output and/or the coolant inlet and/or the coolant outlet of a module is arranged on a base block side surface of the respective module.

25 Advantageously, a plurality of electrical inputs and/or outputs and/or the coolant inlet and/or the coolant outlets are present on different base block side surfaces, so that even planar structures can be plugged together by the modules to form a device.

30 In one aspect of the invention, each of the one or more LED modules is covered by a first transparent component. In a preferred aspect of the invention, each first transparent component covers exactly one LED module. As a result, the sensitive LED modules are protected from physical action, which

can lead to damage. In particular during installation and removal of the module, the contact with the LED modules can lead to damage.

5 In one aspect of the invention, the one or more first transparent components are produced from glass. In a particularly preferred aspect of the invention, the one or more first transparent components are produced from quartz glass. In a further aspect of the invention, the one or more first transparent components consist of sapphire crystal.

10 The one or more first transparent components can be installed fixedly with the LED modules covered by them.

15 According to a further embodiment of the module, the LED luminous area is covered by a second transparent component on the side of the LED module facing away from the base block (top) side. According to a preferred embodiment, the one or more first transparent components are covered by the second transparent component on the side of the one or more first transparent components facing away from the base block (top) side, which protect the LED modules from physical action.

20 The second transparent component is suitable for protecting the components of the module located between the thermally conductive base block and the second transparent component from gases and/or particles which are emitted or produced on the surface of the thermally treated workpiece.

25 The second transparent component can be exchanged and thus prevents the LED modules themselves from having to be exchanged.

30 In one aspect of the invention, the second transparent component is produced from glass. In a particularly preferred aspect of the invention, the second transparent component is produced from quartz glass. In a further aspect of the invention, the second transparent component consists of sapphire crystal.

This prevents damage to and/or soiling of the LED module.

5 According to a further embodiment of the module, the base block side has an area in the range of 1 to 100 cm², preferably 5 to 25 cm².

10 Corresponding variables have proven to be particularly advantageous since these variables are simple to handle. Furthermore, they constitute a compromise between area and thus workpiece size to be thermally treated and electrical power consumption and cooling power consumption.

15 According to further preferred embodiments of the module, the module power density (BPD) is greater than 35 W/cm², more preferably greater than 50 W/cm², more preferably greater than 80 W/cm², more preferably greater than 100 W/cm², more preferably greater than 130 W/cm², more preferably greater than 200 W/cm². The BPD is preferably not greater than 1000 W/cm², more preferably not greater than 600 W/cm², more preferably not greater than 400 W/cm², more preferably not greater than 300 W/cm².

20 According to a preferred embodiment, the module for a device for the thermal treatment of workpieces has the following features:

- a thermally conductive base block with a base block top side, a base block bottom side and base block side surfaces,
- at least one electrical input and at least one electrical output,
- 25 - at least one coolant inlet and at least one coolant outlet,
- an LED luminous area with a luminous surface power density (LPD), wherein the LED luminous area is formed by at least one LED module, wherein the at least one LED module is arranged on the base block top side and is electrically conductively connected to the electrical input and electrical output,
- 30 - a module luminous area with a module power density (BPD), wherein the module power density (BPD) corresponds to the sum of the power of the

LED modules arranged on the base block top side per total area of the base block top side and wherein the module power density (BPD) is greater than 20 W/cm² , preferably greater than 35 W/cm² , more preferably greater than 50 W/cm² , more preferably greater than 80 W/cm² , more preferably greater than 100 W/cm² , more preferably greater than 130 W/cm² , more preferably greater than 200 W/cm² ,

- a separating layer between LED module and base block top side, wherein the separating layer is electrically insulating and thermally conductive.

According to an embodiment of the device, the module luminous areas of the modules form a device luminous area with a device power density (VPD), wherein the device power density (VPD) corresponds to the sum of the power of the LED modules arranged on the base block sides of the modules per total area of the device, wherein the device power density (VPD) is greater than 20 W/cm² , preferably greater than 35 W/cm² , more preferably greater than 50 W/cm² , more preferably greater than 80 W/cm² , more preferably greater than 100 W/cm² , more preferably greater than 130 W/cm² , more preferably greater than 200 W/cm² .

In a preferred aspect, the device power density (VPD) is not greater than 1000 W/cm² , more preferably not greater than 600 W/cm² , more preferably not greater than 400 W/cm² , more preferably not greater than 300 W/cm² .

The device luminous area is defined analogously to the module luminous area as that area which is the total area of the device from which light is emitted, wherein the non-light-emitting regions, such as for example intermediate spaces between LED modules, intermediate spaces between the modules and edge regions, are likewise included.

This enables a thermal treatment of workpieces by means of the device analogously to the statements relating to the module power density (BPD).

According to a development of this embodiment, at a working distance of at least 1 cm, the variation of the device power density (VPD) is less than 20%, preferably less than 10%, more preferably less than 5%.

5 The variation is defined as a percentage deviation from the average value. This enables a uniform thermal treatment of workpieces without local hot spots or excessively cold regions being formed.

10 A correspondingly small variation is achieved, for example, in that the width of the non-luminous edge of the device makes up at most 20%, preferably at most 10%, more preferably at most 5% of the width of the device. More preferably, for this purpose, the width of the non-light-emitting edge of the individual modules is less than 1 mm, preferably less than 2 mm, more preferably less than 3 mm.

15 In an embodiment of the module, the statements relating to the variation also apply to the module.

20 In a further embodiment of the device, the device comprises a process chamber, wherein the at least one module is arranged within or at the process chamber.

25 In an arrangement at the process chamber, the at least one module is preferably arranged on the outer side of a window to the process chamber, such that the light emitted by the at least one module radiates into the process chamber, preferably onto a sample stage or sample holder, in which a workpiece to be treated can be fixed.

30 In a process chamber, the ambient conditions for the material properties of the workpiece to be treated can advantageously be set. For example, the chamber can contain a reduced air pressure down to the vacuum or protective gases in order to protect the workpieces to be treated from oxidation.

Furthermore, a process chamber in which a reduced air pressure down to the vacuum can be generated has a particularly advantageous effect on the efficiency when using light in the region of short wavelengths.

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Alternatively, the atmosphere in the chamber can also contain process gases. The chamber can be embodied both as a closed chamber and also open on one or more sides, in order that, for example, a continuous through-flow of workpieces to be treated is made possible.

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The process chamber can contain a receptacle for workpieces. A receptacle for workpieces can be embodied in a variety of ways. For example, it can be an insulating base on which the workpieces are positioned, or it can be a mechanism which allows powder to trickle down in the case. Preferably, the outer environment of the device is shielded by the process chamber from the LED light emitted within the process chamber.

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In a further embodiment of the device, the device has mirrors in the outer edge regions of the area formed from the modules, which mirrors are configured to reflect light emitted laterally by the module luminous areas, preferably in the direction of a workpiece to be treated.

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At the outer edge regions of the area formed by the modules, the power density of the LED light can drop toward the outside and tend toward zero, the further away from the area formed by the modules. As a result, in some cases, the entire area formed cannot be used for processing. The area usable for processing can thus be enlarged by a corresponding arrangement and alignment of the mirrors in the outer edge regions of the area formed from the modules.

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The workpieces are heated to very high temperatures, for example 1100°C., during the thermal treatment by modules according to the invention.

The inventors have recognized that evaporations from the treated workpiece or reactions on the surface of the treated workpiece can typically occur in this case. The inventors have also recognized that the particles and/or gases produced or emitted therefrom can damage sensitive components due to the high temperatures, for example by firing. The described particles and/or gases which occur during the heating of workpieces can lead to damage to the LED modules of the module according to the invention. If particles and/or gases of the workpieces burn into the LED modules, the performance of the module is impaired. In addition, the power density across the module is reduced and non-uniform, so that workpieces can no longer be thermally treated strongly enough and uniformly. Consequently, LED modules then have to be replaced.

It is therefore also an object of the invention to increase the service life of the modules for the thermal treatment of workpieces with unchanged effectiveness.

The solution of this object is made possible by a suction device according to the invention.

The suction device according to the invention for suctioning particles and/or gases which are emitted or produced on a surface of a treated workpiece during a thermal treatment of the workpiece with the aid of a module according to the invention or of a device according to the invention comprises a turbomachine, one or more lines and a suction nozzle. The lines couple the turbomachine to the suction nozzle, which is configured in such a way that, in conjunction with the turbomachine, it is suitable for generating a (primarily) laminar flow outside the suction device and in a surrounding area of the suction nozzle.

As a result of the (substantially) laminar flow generated in this way, the particles and/or gases are discharged through the suction device before they

can reach the LED luminous areas of the LED modules, as a result of which the service life of the module is increased.

5 This lengthening of the service life is achieved without reducing the effectiveness of the thermal treatment.

10 On the one hand, an installation of a transparent component, such as for example a quartz glass, can be dispensed with, which reduces optical losses on the path between LED modules and workpiece.

15 On the other hand, convections are reduced. If a flow is generated in the surrounding area of the workpiece to be treated, heat can be dissipated to an increased extent from the workpiece to the surrounding area by convection, so that a higher power density of the module is necessary in order to achieve the same temperature in the workpiece. The suction device according to the invention reduces this effect of convection by generating a (primarily) laminar flow, that is to say less turbulence arises, which would result in convection of heat away from the workpiece to be treated.

20 The suction device according to the invention thus allows the protection of the modules according to the invention against particles and/or gases which are emitted or produced without significantly reducing the effectiveness, as a result of which the longevity and effectiveness of the modules is ensured.

25 In one aspect of the invention, the turbomachine is a fan. Other turbomachines can likewise be used, such as, for example, fans and compressors.

30 The turbomachine is coupled to the suction nozzle by the lines, so that a pressure difference between the interior of the suction nozzle and the outer environment of the suction nozzle arises at the input of the suction nozzle.

The suction nozzle is configured in such a way that, in conjunction with the one or more lines and the turbomachine, a laminar flow of the fluid is caused in the surrounding area of the suction nozzle.

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The configuration of the suction nozzle can be dependent on the turbomachine and the coupling or connection between suction nozzle and turbomachine.

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Laminar flows are distinguished by the fact that they contain substantially no turbulence or vortices. If a laminar flow arises in a region between two objects, it is therefore substantially ensured that the surrounding area of each object remains undisturbed by the flow. However, the flow forms a threshold for gases and/or particles which are produced on or in one object and move along trajectories in the direction of the other object, since they are absorbed in the flow on the trajectory from one object to the other and carried away along the flow.

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In a preferred aspect of the invention, the suction device, the one or more modules according to the invention and the workpiece to be treated are arranged in such a way that the (preferably) laminar flow arises between the LED luminous areas of the one or more modules and the workpiece to be treated.

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In a particularly preferred aspect, the (substantially) laminar flow is directed obliquely with respect to a plane perpendicular to at least one of the one or more LED luminous areas of the one or more modules. Thus, it can be ensured that particles and/or gases which are produced or emitted on a surface of the workpiece and whose trajectory leads in the direction of the LED luminous areas are intercepted by the flow and carried away from the LED luminous areas. Since substantially no vortices occur in this case,

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convection arises only to a very small extent, so that substantially no heat flows away from the workpiece.

5 In a further particularly preferred aspect, an intersection point of the (primarily) laminar flow with the plane perpendicular to at least one of the one or more LED luminous areas of the one or more modules lies in the light field of the LED luminous areas of the one or more modules. An effective protection of the LED luminous areas is ensured as a result. The (primarily) laminar flow is regularly not one-dimensionally pronounced. There is therefore more than 10 one intersection point of the flow with the designated plane. It is sufficient if at least one intersection point lies in the light field of the LED luminous areas of the one or more modules. The amount of the spatial points which the light emitted by the one or more LED luminous areas of the one or more modules passes through is designated as the light field.

15 The suction device can also contain filters which are suitable for filtering out suctioned gases and/or particles so that they do not reach the turbomachine, for example, and damage it or are emitted again from the suction device.

20 The suction device can also be used in conjunction with a plurality of modules or a device according to the invention comprising one or more modules. In particular, a suction device which comprises a process chamber can likewise be used with one embodiment of the device.

25 In a further aspect of the invention, the suction device can also comprise a blowing device. In this case, the blowing device can be arranged in such a way that it brings about a flow of a fluid towards the suction nozzle. The suction region of the suction device is enlarged as a result. For example, when using 30 a device according to the invention consisting of a plurality of modules according to the invention, a large LED luminous area can have to be protected. In order to meet this, the described embodiment is particularly suitable. In a

preferred aspect of the invention, the blowing device brings about a substantially laminar flow which is directed towards the suction nozzle.

5 In a further aspect of the invention, a plurality of suction devices can be used together.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The invention is explained in more detail below with reference to the attached drawings. In the drawings:

FIG. 1a shows an embodiment of a module for a device for the thermal treatment of workpieces with a cooling device,

15 FIG. 1b shows an embodiment of a module for a device for the thermal treatment of workpieces,

FIG. 2 shows a further view of the embodiment from FIG. 1b,

20 FIG. 3 shows a further embodiment of a module for a device for the thermal treatment of workpieces,

FIG. 4 shows a further view of the embodiment from FIG. 3,

25 FIG. 5 shows an embodiment of a device for the thermal treatment of workpieces with modules,

FIG. 6 shows an embodiment of a base body of a module for a device for the thermal treatment of workpieces,

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FIG. 7 shows an embodiment of a device for the thermal treatment of workpieces comprising a process chamber and modules,

FIG. 8 shows an embodiment of the system comprising a module for the thermal treatment of a workpiece, a workpiece to be treated and a suction device,

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FIG. 9 shows a front view of an embodiment of a suction nozzle for a suction device,

FIG. 10 shows a) a lateral view and b) a cross section, parallel thereto, of a suction nozzle for a suction device,

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Components which are illustrated in a plurality of figures bear the same reference symbols.

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DETAILED DESCRIPTION

FIG. 1 a describes a first embodiment of a module 1 for a device for the thermal treatment of workpieces. The module 1 has a base block 2 which consists of a thermally conductive material, for example copper. One or more LED modules 10 are arranged on a base block side 3. The embodiment shown by way of example in FIG. 1 a comprises 45 LED modules. The LED modules 10 preferably have an electrical contacting option, a socket and at least one LED chip. An LED module 10 can have a plurality of sockets and LED chips. The actually light-emitting region of an LED module 10 is formed precisely by the sum of the area of the respective LED chips of the LED module 10.

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The module 1 comprises a module luminous area 18 with a module power density BPD, wherein the module power density BPD corresponds to the sum of the power of the LED modules 10 arranged on the base block side 3 per total area of the base block side 3.

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FIG. 1 a furthermore shows an optional cooling device 1100 configured to bring the base block 2 into thermal contact with a coolant 14 . Such a coolant 14 can be, for example, a dielectric liquid. Due to the high coefficient of thermal conductivity of many liquids in comparison with air and other gases, a more efficient and more powerful heat dissipation from the base block is thus ensured. However, the coolant 14 is not restricted to such liquids.

The cooling device 1100 furthermore comprises an optional coolant inlet 8 and an optional coolant outlet 9 . The number of inlets and outlets is not restricted hereby. With the aid of this inlet and outlet, the coolant 14 can be circulated, so that the cooling of the base block and thus of the entire module can dissipate even more heat, as a result of which higher power densities of the module are enabled.

Electrical inputs 6 and outputs 7 can be arranged on all sides of the base block and configured such that electrical contact between inlets 6 and outlets 7 and the LED modules is enabled. In particular, electrical inlets 6 and outlets 7 when using dielectric liquids can be such, due to the dielectric properties, that they come into contact with the liquid. Exemplary embodiments and locations of electrical inlets and outlets are also illustrated in the following figures.

The geometric form of the base block 2 and thus of the module 1 is not limited to rectangles. Any type of polygon is possible, wherein polygons with which a complete surface filling is possible are preferred, since otherwise non-luminous intermediate spaces arise.

FIG. 1 b describes a further embodiment of a module 1 for a device for the thermal treatment of workpieces in a perspective view of the module 1 obliquely from above. FIG. 2 shows the same module in a perspective view obliquely from below. The module has a thermally conductive base block 2 with a base block top side 3, a base block bottom side 4 and base block side

surfaces 5 . The distance between base block top side 3 and base block bottom side 4 defines the thickness d of the base block 2 .

5 A plurality of LED modules 10 are arranged on the base block top side 3, wherein the light-emitting regions of the LED modules 10 in total form an LED luminous area 11 which has a luminous surface power density LPD. The LED modules 10 have an electrical contacting option, a socket and at least one LED chip. An LED module 10 can have a plurality of sockets and LED chips. The actually light-emitting region of an LED module 10 is formed precisely by the sum of the area of the respective LED chips of the LED module 10 .

15 The luminous surface power density LPD results from the power, emitted as light, per LED luminous area 11 .

20 The module 1 comprises a module luminous area 18 with a module power density BPD, wherein the module power density BPD corresponds to the sum of the power of the LED modules 10 arranged on the base block top side 3 per total area of the base block top side 3 . In the present rectangular base block 2, the total area of the base block top side 3 is calculated from the lengths of the base block side surfaces 5 .

25 On the base block bottom side 4, a respective electrical input 6 and an electrical output 7 are arranged, which can be contacted, for example, in the form of electrical plug connections. This electrical input 6 and electrical output 7 are led through from the base block bottom side 4 to the base block top side 3, so that the individual LED modules 10 can be electrically contacted.

30 Furthermore, a respective optional coolant inlet 8 and an optional coolant outlet 9 are arranged on the base block bottom side 4 . Via the coolant inlet 8, a coolant 14 can be conducted into the interior of the base block 2, where the coolant absorbs the waste heat of the LED modules 10 arranged

on the base block top side 3 . Via the coolant outlet 9, the coolant 14 is conducted out of the interior of the base block 2, so that an effective cooling of the base block 2 is possible.

5 Furthermore, mechanical connection possibilities 15 are provided on the base block bottom side 4 . In FIG. 2, these are embodied as bores with threads, but alternative connection and fastening possibilities are also possible. Via the mechanical connection possibilities 15, the module 1 can be fastened to a holder or supporting structure.

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 The base block 2 consists of a thermally conductive material, for example copper, and can have in its interior one or more channels 13, such as a lamellar structure, allowing flow of a coolant 14, for example water. A corresponding structure of channels 13, such as a lamellar structure, is shown in
15 FIG. 6, wherein the coolant inlet 8 and coolant outlet 9 are arranged differently on base block side surfaces 5 .

 The module power density BPD is more than 20 W/cm² . This already enables a sufficient input of energy into the surface of some workpieces to be
20 thermally treated. For example, it is possible to heat a workpiece which absorbs very well to temperatures of 1100°C.

 The module power density BPD can advantageously be increased as required, preferably to greater than 35 W/cm² , more preferably greater than
25 50 W/cm² , more preferably greater than 80 W/cm² , more preferably greater than 100 W/cm² , more preferably greater than 130 W/cm² , more preferably greater than 200 W/cm² . A higher input of energy into the surface of workpieces to be thermally treated is made possible as a result. However, the module power density BPD is less than 1000 W/cm² , preferably less than
30 600 W/cm² , more preferably less than 400 W/cm² , more preferably less than 300 W/cm² .

FIG. 3 shows a further embodiment of a module 1 for a device for the thermal treatment of workpieces. In this case, a plurality of electrical inputs 6 and a plurality of electrical outputs 7 and a plurality of coolant inlets 8 and a plurality of coolant outlets 9 are arranged on the base block side surfaces 5 .

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By means of the arrangement of the respective inputs and outputs 6, 7, 8, 9 on the base block side surfaces 5, it is possible in a simple manner to connect a plurality of modules 1 to form a device 100, as illustrated in FIG. 5 . The respective inputs and outputs 6, 7, 8, 9 are preferably designed as plug connections or corresponding couplings.

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The presence in particular of a plurality of electrical inputs and outputs 6, 7 furthermore enables driving of individual LED modules 10 or LED module groups 17 . As a result, it is possible for specific regions of the module luminous area 18 to emit light, while other regions are dark. An LED module group 17 is formed in this case by a combination of individual LED modules 10 (see FIG. 5).

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FIG. 4 shows a view of the embodiment from FIG. 3 in a side view. The illustrated electrically insulating and thermally conductive separating layer 12 between the LED modules 10 and the base block top side 3 is also provided in the exemplary embodiments from FIGS. 1a and 1b. The separating layer 12 is preferably formed from aluminum nitride. The separating layer 12 does not have to be applied over the full area on the base block top side 3. For example, the separating layer 12 can be provided only in the regions on the base block top side 3 in which an LED module 10 is arranged. The separating layer can have various thicknesses. In preferred embodiments, the separating layer is less than 500 μm , more preferably less than 425 μm , more preferably less than 350 μm , more preferably less than 275 μm , more preferably less than 200 μm , more preferably less than 100 μm , more preferably less than 40 μm , more preferably less than 10 μm , more preferably less than

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2 μm thick. In a particularly preferred embodiment, the thickness of the separating layer is 375 μm .

5 FIG. 4 furthermore shows an optional transparent component, for example a glass pane 16 (e.g. quartz glass), on the side of the LED modules 10 facing away from the base block top side 3. As a result, damage to and/or soiling of the LED modules 10 can be prevented. In particular during a thermal treatment of a workpiece using a module 1, gases, vapors or other particles which contaminate the LED modules 10 can be emitted from the work-
10 piece or produced on the surface of the workpiece. Furthermore, particles, gases or vapors can burn into the LED modules during the thermal treatment due to the high temperatures in the workpiece, so that they are no longer functional and have to be replaced.

15 FIG. 5 shows an embodiment of a device 100 for the thermal treatment of workpieces having a plurality of modules 1.

 The device 100 is formed by a plurality of modules 1 a to 1 l. In the present case, each module has a plurality of electrical inputs 6 and a plurality of
20 electrical outputs 7 and a plurality of coolant inlets 8 and a plurality of coolant outlets 9.

 The enlargement in FIG. 5 shows, with reference to the connection between the modules 1 k and 1 l, how a respective electrical input 6 k of the
25 module 1 k is connected to an electrical output 7 l of the module 1 l, and an electrical input 6 l of the module 1 l is connected to an electrical output 7 k of the module 1 k. This applies analogously to the coolant inlet 8 k and coolant outlet 9 l, and to the coolant inlet 8 l and coolant outlet 9 k.

30 The module luminous areas 18 of the modules 1 a to 1 l form a device luminous area 111 with a device power density VPD, wherein the device power density VPD corresponds to the sum of the power of the LED modules

10 arranged on the base block top sides 3 of the modules 1 a to 1 l per total area of the device. The device luminous area 111 is defined analogously to the module luminous area 18 as that area which corresponds to the total area of the device 100 from which light is emitted, wherein the non-light-emitting regions, such as for example intermediate spaces between LED modules 10, intermediate spaces between the modules 1 a to 1 l and edge regions, are likewise included.

The geometric form of the device 100 is not limited to rectangles. Any type of polygon is possible. In particular, three-dimensional, that is to say not only planar, devices 100 can also be formed depending on the geometric form of the modules 1. For this purpose, it is particularly advantageous to combine modules 1 of different geometries.

FIG. 7 shows a further embodiment of the device 100, wherein the device 100 additionally comprises a process chamber 110. The device 100 comprises modules 1 a, 1 b in a known manner, wherein the modules 1 a, 1 b consist in a known manner of a base block 2 with base block top side 3 and base block bottom side 4 and the further features illustrated in FIGS. 1 to 4. A device luminous area 111 is formed by the LED luminous area 11 of the modules 1 a, 1 b.

In the arrangement illustrated in FIG. 7, the modules 1 a, 1 b are arranged in the process chamber 110, such that the light emitted by the device luminous area 111 can radiate onto receptacle 120, for example a sample stage or sample holder. It is also possible to arrange the modules 1 a, 1 b on the outer side of a window of the process chamber 110, such that the light emitted by the at least one module 1 radiates into the process chamber 110, preferably onto the workpiece to be treated arranged in the receptacle 120.

FIG. 8 shows an embodiment of a suction device 200 according to the invention, comprising a turbomachine 201, lines 202 and a suction nozzle

203 . The lines 202 couple the turbomachine 201 to the suction nozzle 203, such that a pressure ratio not equal to 1 arises at the suction nozzle between interior and outer environment. The suction nozzle 203 is configured in such a way that a laminar flow 205 arises in a surrounding area of the suction nozzle. The configuration of the suction nozzle 203 can be dependent on the turbomachine 201, the power provided by the turbomachine 201 and on the lines 202 .

FIG. 8 also shows a module 1 according to the invention and a workpiece 204 to be thermally treated. The suction device and the module are arranged with respect to the workpiece in such a way that the laminar flow 205 arising in a surrounding area of the suction nozzle arises between the LED luminous area 11 of the module 1 and the workpiece 204 . The laminar flow is also directed obliquely with respect to a plane perpendicular to the LED luminous area 11 . In addition, at least one intersection point of the laminar flow with at least one such plane lies in the light field of the LED luminous areas of the module 1 . Any gases and/or particles which are produced or emitted on or in the surface of the workpiece 204 to be treated are thereby absorbed and carried away in the flow, so that the gases and/or particles do not reach the LED luminous area 11 . The risk of soiling and damage to the module is thus considerably reduced.

Owing to the properties of the laminar flow 205, that is to say the layering of the flow speed, no turbulence and vortices arise. The thermal treatment of the workpiece 204 is thus not inhibited by the suction device 200, since convection which transports heat away from the workpiece 204 to be treated does not arise. This is advantageous in particular in comparison with other protective devices such as, for example, glass panes, since an inhibitor for the radiation is introduced into the beam path of the light as a result. Absorption and reflection cause power losses, as a result of which the thermal treatment is in turn inhibited.

FIG. 9 shows a front view of an embodiment of the suction nozzle 203 in FIG. 8 . In this case, the white area constitutes an opening of the nozzle through which gases and/or particles can be suctioned.

5 FIG. 10 shows a) an exemplary lateral view and b) an exemplary cross section of an embodiment of the suction nozzle 203 . In this embodiment, the suction nozzle comprises a rounded lip 206 . The suction nozzle 203, in particular the lip 206, is configured in conjunction with the remaining structure of the suction device (turbomachine 201 and lines 202) in such a way that the
10 flow arising in a surrounding area of the suction nozzle 203 is laminar (see arrows in FIG. 8). This is achieved particularly effectively, for example, by the rounded form of the lip 206 since, in particular, edge-free areas promote the formation of laminar flows. The entry of the laminar flow into the opening of the suction nozzle 203 is then also hardly disturbed by vortices during the
15 opening. Further configurations of the suction nozzle and other parts of the system according to the invention can be implemented.

Preferred embodiments of the subject matter claimed by the appended claims are described in the description and in the figures. The optional features disclosed in the above description, the claims and the drawings can be
20 used both individually and in any desired combination for the embodiment of the subject matter claimed here according to the attached claims in its various configurations.

25 The various aspects and embodiments described above can be combined in order to create yet further embodiments. These and other changes can be made to the embodiments in the light of the above detailed description. In general, the terms used in the following claims should not be interpreted such that they restrict the claims to the specific aspects and embodiments disclosed in the description and the claims, but such that they comprise
30 all possible embodiments together with the full scope of the equivalents to which these claims are entitled.

Claims

- 5 1. A module (1) for a device (100) for the thermal treatment of work-
pieces, comprising:
- a thermally conductive base block (2) with a base block side (3),
 - at least one electrical input (6),
 - an LED luminous area (11), wherein the LED luminous area (11) is
10 formed by at least one LED module (10), wherein the at least one
LED module (10) is arranged on the base block side (3) and is electri-
cally conductively connected to the electrical input (6),
 - a module luminous area (18) with a module power density (BPD),
wherein the module power density (BPD) corresponds to the sum of
the power, emitted as light, of the LED modules arranged on the base
15 block side (3) per total area of the base block side (3),
 - a separating layer (12) between LED module (10) and base block
side (3), wherein the separating layer (12) is thermally conductive,
characterized in that
the module (1) further comprises at least one electrical output (7) to
20 which the at least one LED module (10) is electrically conductively
connected, in that the separating layer (12) is electrically insulating,
and in that the module power density (BPD) is greater than 20 W/cm².
- 25 2. The module (1) according to claim 1, wherein the base block side (3) is a
base block top side (3) and the base block (2) further comprises a base
block bottom side (4) and base block side surfaces (5), the module fur-
ther comprising:
at least one coolant inlet (8) and at least one coolant outlet (9),
30 wherein the LED luminous surface has a luminous surface power density
(LPD).

3. The module (1) according to claim 1, further comprising a cooling device configured to bring the base block into thermal contact with a coolant.
- 5 4. The module (1) according to claim 3, the cooling device further comprising at least one coolant inlet (8) and at least one coolant outlet (9).
- 10 5. The module (1) according to claim 4, wherein the cooling device is configured to receive a coolant via the coolant inlet (8) in the base block and to discharge the received coolant via the coolant outlet (9) from the base block.
- 15 6. The module (1) according to any one of the preceding claims, **characterized in that** the LED luminous area (11) covers at least 60%, preferably at least 70%, more preferably at least 80%, more preferably at least 90% of the base block top side (3).
- 20 7. The module (1) according to any one of the preceding claims, **characterized in that** a plurality of LED modules (10) form the LED luminous area (11) of the module (1) and the LED modules (10) are configured to emit different wavelength ranges.
- 25 8. The module (1) according to claim 7, wherein a first wavelength range is in the range 425 to 600 nm and a second wavelength range is in the range 200 to 425 nm.
- 30 9. The module according to any one of the preceding claims, **characterized in that** a plurality of LED modules (10) form the LED luminous area (11) and a plurality of electrical inputs (6) and outputs (7) are present, which are each electrically conductively connected to an LED module (10) or an LED module group (17).

10. The module (1) according to any one of the preceding claims, **characterized in that** the base block (2) has one or more channels (13), preferably a lamellar structure, allowing flow of a coolant (14), preferably a cooling fluid, via the coolant inlet (8) and coolant outlet (9).
- 5
11. The module (1) according to any one of the preceding claims, **characterized in that** the distance between the base block top side (3) and a coolant (14) introducible via the coolant inlet (8) is less than 1 cm.
- 10
12. The module (1) according to any one of the preceding claims, wherein the base block side (3) is a base block top side facing the workpiece to be treated and the base block preferably further comprises a base block bottom side (2) and base block side surfaces (5).
- 15
13. The module (1) according to any one of claims 2-12, **characterized in that** the electrical input (6) and/or electrical output (7) and/or the coolant inlet (8) and/or the coolant outlet (9) are arranged on the base block bottom side (2).
- 20
14. The module (1) according to any one of claims 2 to 12, **characterized in that** the electrical input (6) and/or electrical output (7) and/or the coolant inlet (8) and/or the coolant outlet (9) are arranged on a base block side surface (2).
- 25
15. The module (1) according to any one of the preceding claims, **characterized in that** each LED module of at least a part of the at least one LED module (10) is covered by a first transparent component, preferably a glass pane, on the side of the LED module (10) facing away from the base block side (3).
- 30
16. The module (1) according to any one of claims 1 to 15, **characterized in that** the LED luminous area (11) is covered by a second transparent

component (16), preferably a glass pane, on the side of the LED module (10) facing away from the base block side (3).

- 5 17. The module (1) according to claim 16, **characterized in that** the first transparent component is arranged between the respective LED module (10) and the second transparent component.
- 10 18. The module according to any one of the preceding claims, **characterized in that** the LED luminous area (11) is covered by a quartz glass (16) on the side of the LED module (10) facing away from the base block top side (3).
- 15 19. The module (1) according to any one of the preceding claims, **characterized in that** the base block top side (3) has an area in the range of 1 to 100 cm², preferably 5 to 25 cm².
- 20 20. The module (1) according to any one of the preceding claims, wherein the module power density (BPD) is greater than 35 W/cm² , preferably greater than 50 W/cm² , more preferably greater than 80 W/cm² , more preferably greater than 100 W/cm² , more preferably greater than 130 W/cm² , more preferably greater than 200 W/cm² .
- 25 21. The module (1) according to any one of the preceding claims, wherein the module power density (BPD) is not greater than 1000 W/cm² , preferably not greater than 600 W/cm² , preferably not greater than 400 W/cm² , more preferably not greater than 300 W/cm² .
- 30 22. The module (1) according to any one of the preceding claims, wherein the LED luminous area (11) has a luminous surface power density (LPD) which results from the power, emitted as light, per LED luminous area.

23. The module (1) according to any one of the preceding claims, wherein the separating layer (12) has a thickness of less than 500 μm , preferably less than 425 μm , more preferably less than 350 μm , more preferably less than 275 μm , more preferably less than 200 μm , more preferably less than 100 μm , more preferably less than 40 μm , more preferably less than 10 μm , more preferably less than 2 μm .
24. A device (100) for the thermal treatment of workpieces, **characterized in that** the device (100) comprises at least one module (1) according to any one of claims 1 to 23.
25. The device (100) according to claim 24, **characterized in that** the device (100) is formed and/or expandable in a modular manner by modules (1) arranged next to each other.
26. The device (100) according to claim 25, **characterized in that** a respective electrical input (6) and/or coolant inlet (8) of a subsequent module (1) is connected to an electrical output (7) and/or coolant outlet (9) of a preceding module (1).
27. The device (100) according to any one of claims 24 to 26, wherein the module luminous areas (18) of the modules (1) form a device luminous area (111) with a device power density (VPD), wherein the device power density (VPD) corresponds to the sum of the power of the LED modules arranged on the base block top sides (3) of the modules (1) per total area of the device (1), **characterized in that** the device power density (VPD) is greater than 20 W/cm².
28. The device (100) according to claim 27, **characterized in that**, at a working distance of at least 1 cm, the variation of the device power density (VPD) is less than 20%, preferably less than 10%, more preferably less

than 5%.

- 5 29. The device (100) according to any one of claims 24 to 28, **characterized** in **that** the device (100) comprises a process chamber (110), wherein the at least one module (1) is arranged within or at the process chamber (110).
- 10 30. The device (100) according to any one of claims 24 to 29, wherein the device power density (VPD) is greater than 35 W/cm² , preferably greater than 50 W/cm² , more preferably greater than 80 W/cm² , more preferably greater than 100 W/cm² , more preferably greater than 130 W/cm² , more preferably greater than 200 W/cm² .
- 15 31. The device (100) according to any one of claims 24 to 30, wherein the device power density (VPD) is not greater than 1000 W/cm² , preferably not greater than 400 W/cm² , more preferably not greater than 300 W/cm² .
- 20 32. Use of a module (1) according to any one of claims 1 to 23 or of a device (100) according to any one of claims 24 to 31, for the thermal treatment of a workpiece, preferably for the thermal treatment at temperatures greater than 500°C.
- 25 33. A suction device (200) for suctioning gases and/or particles which are emitted or produced on a surface of a treated workpiece (204) during a thermal treatment of the workpiece (204) with the aid of a module (1) or of a device (100) according to the preceding claims, comprising:
- a turbomachine (201),
 - one or more lines (202), and
 - 30 - a suction nozzle (203),
- wherein the lines (202) couple the turbomachine (201) to the suction nozzle (203) and the suction nozzle (203) is configured in such a way that, in

conjunction with the one or more lines and the turbomachine (201), it is suitable for generating a laminar flow (205) outside the suction device (200) and in a surrounding area of the suction nozzle (203).

- 5 34. The suction device (200) according to claim 33, further comprising a blowing device which can be arranged with respect to the suction nozzle in such a way that it is suitable for generating a flow of a fluid towards the suction nozzle, such that the suction region of the suction nozzle is enlarged.
- 10
35. Use of a suction device (200) according to claims 33 to 34 for suctioning gases and/or particles which are emitted or produced on a surface of a treated workpiece (204) during a thermal treatment of the workpiece (204), preferably with the aid of a module (1) or of a device (100) according to the preceding claims.
- 15
36. A system comprising:
- one or more modules (1) according to claims 1 to 23,
 - and
 - 20 - one or more suction devices (200) according to claims 33 to 34,
- wherein the one or more modules (1) and the one or more suction devices (200) can be arranged relative to a workpiece (204) in such a way that the laminar flow (205) generated by the one or more suction devices (200) arises between the workpiece (204) and the LED luminous areas of
- 25 the one or more modules (1) and is directed obliquely with respect to a plane perpendicular to at least one of the one or more LED luminous areas of the one or more modules (1).
37. The system according to claim 36, wherein an intersection point of the
- 30 generated laminar flow with the plane perpendicular to at least one of the one or more LED luminous areas of the one or more modules (1) lies in

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the light field of the one or more LED luminous areas of the one or more modules (1).